

ANALYSIS OF A WARM "COLD FRONT"

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The airway forecaster has an exceptionally favorable opportunity to study the peculiar action of fronts at first hand. His maps drawn at frequent intervals sometimes reveal, along the cold front, unusual action which at first sight appears entirely opposite to the manner in which a normal front should and does act. Such a case was observed by the writer on October 26, 1933, when the weather along several hundred miles of a cold front cleared up some 50 miles in advance of the wind-shift line and remained practically clear during the passage of the shift, contrary to the usual occurrence of turbulent convection and low overcast skies. Careful study of the conditions involved showed that they were exceptional, and that the apparently unusual action was exactly what should be expected under the circumstances.

The original barometric distribution was a trough extending from Minnesota southwestward to the Texas Panhandle, with a rather well-defined, nearly straight, surface wind-shift line extending from western Iowa to the Texas Panhandle. This line was, of course, advancing eastward, and at 7 a. m. of October 26 had not yet passed Omaha. West of this line the winds aloft above 2,000 feet were nearly all northwest up to 12,000 feet. East of this line they were mostly southwest, but with some west winds at certain levels in Texas and Oklahoma.

By 11 a. m. the front had passed Tarkio, Mo., and Waynoka, Okla., but had not reached Wichita, Kans., nor St. Joseph, Mo. At that time generally cloudy weather with mist, light rain and light fog, and ceilings varying from 400 feet to 4,000 feet existed on the eastern side of the trough, over eastern Oklahoma, southeastern Kansas, and most of Missouri except the northwest corner. In this sector the cloudy, rainy weather kept the temperatures in the middle forties. On the polar side the early morning temperatures had been in the forties, but since only scattered to broken high clouds, mostly of the cirrus type, prevailed on that side of the front, there was a material rise in the surface temperature due to insolation. The temperatures there rose from the upper forties to 60° or higher, which was a strong indication of an inversion existing in the early morning. Both the Dallas and Omaha airplane flights showed morning inversions, and apparently the inversion on the eastern side was maintained during the day by the cloudy condition.

Clearing was first noted on the 11 a. m. map, when stations a considerable distance in advance of the surface wind-shift reported scattered clouds where they had previously reported overcast with ceilings below 2,000 feet. Wichita at that time reported a south wind, and strato-cumulus clouds from the northwest.

The clearing continued in advance of the front on the 3 p. m. map. At 2:42 p. m. Kansas City reported clouds from the northwest at an elevation of about 2,500 feet above the surface, but the surface wind did not shift to northwest until 4:30 p. m. or about 2 hours later. The velocity remained around 5 or 6 miles per hour, and it is obvious that such lag in the surface wind-shift was not due to surface drag.

By measurement on successive maps it was determined that the front advanced about 240 miles in 12 hours or approximately at the rate of 20 miles per hour. Since the wind shifted at the 2,500-foot level about 2 hours earlier than at the surface, it follows that if the front advanced at the same rate aloft (a logical assumption) the front at the 2,500-foot level was some 40 miles ahead of the surface wind-shift. The balloon observation at Kansas City at 4:38 p. m. (a few minutes after the surface wind-shift) showed that the wind-shift had passed at all levels up to 12,000 feet. The Omaha 5 a. m. balloon observation showed that it had passed at all levels except the lower 2,000 feet, which indicated that the front lagged only in the lower levels.

Visual observations of clouds at Kansas City indicated that the wind-shift occurred aloft far in advance of the surface shift, and cloud movements indicated that the cooler air to the east of the wind-shift (often of tropical origin, but in this case returning polar air) extended under the warmer polar air in a wedge shape similar to the manner in which polar air usually invades equatorial air. Doubtless this was due to the greater density of the northward moving modified polar air, as its temperature was kept down by the cloudy condition existing on this side, that is to the east of the wind-shift line. Earlier observations in the day indicated that clouds existed to a level of at least 4,000 feet, and very likely these higher clouds cleared away first as the comparatively dry polar air replaced the more moist modified polar air; and breaks began to appear in the lower clouds (which were at an altitude of about 2,500 feet) while the wind at that level was still southwest. As the clearing took place the wind at the lower cloud level shifted to northwest, and about 2 hours later shifted at the surface. Meanwhile the temperature was rising and reached its maximum point at about the time of the surface wind shift.

Ordinarily, strong convection and turbulence would result from the polar air flowing in aloft first; but in this case the temperature of the air in the under levels had been lower than that of the polar air until the clearing occurred, when it apparently rose to about the same value as that of the surface polar air; and there was, of course, no strong lapse rate to produce convection.

While the conditions described above are unusual, they are not so rare as to be considered entirely abnormal. Fronts with important features similar to those described, but also with variations, occur often enough in the middle west for conclusions drawn from an analysis of this kind to be of value in actual forecast work. A front of the kind described can be detected from the wind-aloft reports, combined with surface reports, and temperatures on the two sides of the front line. By a careful estimate of rate of movement of the front, the time of clearing conditions in a case of this kind can be forecast with considerable accuracy for several hours in advance, once the condition has been properly analyzed by the forecaster.